



Indexing Farmers' Seed Lots for Seed-Borne Organisms and Response to Seed Disinfectants

BY R. H. PORTER, W. E. HENDERSHOTT AND G. N. DAVIS

**AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS**

R. E. BUCHANAN, Director

BOTANY AND PLANT PATHOLOGY SECTION

**BUREAU OF PLANT INDUSTRY
UNITED STATES DEPARTMENT OF AGRICULTURE**

Cooperating



**RESEARCH BULLETIN 238
SEPTEMBER, 1938
AMES, IOWA**

September, 1938

Research Bulletin 238

Indexing Farmers' Seed Lots for Seed-Borne Organisms and Response to Seed Disinfectants

BY R. H. PORTER, W. E. HENDERSHOTT AND G. N. DAVIS

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

R. E. BUCHANAN, Director

BOTANY AND PLANT PATHOLOGY SECTION

BUREAU OF PLANT INDUSTRY
UNITED STATES DEPARTMENT OF AGRICULTURE

Cooperating

AMES, IOWA

CONTENTS

	Page
Summary	243
Materials and methods.....	246
Varieties of crops used.....	248
Trials with barley.....	249
Results in 1933.....	249
Farmers' seed samples.....	249
Seed from five standard varieties.....	250
Results in 1934.....	254
Results in 1935 and 1936.....	256
Trials with other seed disinfectants.....	257
Rate of seeding in relation to seed treatment.....	258
Discussion of barley trials.....	259
Trials with oats.....	260
Discussion of oat trials.....	264
Trials with wheat.....	264
Discussion of wheat trials.....	265
Trials with flax.....	266
Discussion of flax trials.....	268
Trials with corn.....	268
Discussion of corn trials.....	271
Literature cited.....	272

SUMMARY

Laboratory and field germination tests with 129 seed lots of barley, 123 of corn, 75 of flax, 110 of oats and 21 of wheat were conducted in the years 1932-36 inclusive. In addition to the determination of viability, two phytopathological techniques, namely, examination for the presence of seed-borne pathogens and determination of the effect of seed disinfectants, were employed, all of which aided in measuring seeding value or response in the field of each lot. A summary of the results obtained follows:

1. Laboratory detection of *Gibberella saubinetii* and related species of *Fusarium*, *Helminthosporium sativum* and other species of *Helminthosporium* on seed samples of barley, oats and wheat was found to be possible by an examination of the seedlings when germinated on top of moist blotters at 20°C. Further evidence of the scab organisms, *Gibberella saubinetii* and *Fusarium spp.*, was obtained by the development of blighted seedlings grown in autoclaved soil mixed in equal proportions with sand.

2. Detection of the corn dry rot organisms, principally *Diplodia zeae*, *Gibberella saubinetii* and *Fusarium spp.*, was shown to be possible in a seed laboratory by making a critical examination of the seedlings produced on top of moist blotters at temperatures of 24-27°C. *Basisporium gallarum* was more readily detected by careful examination of ungerminated, severely infected seed.

3. The presence of the several seed-borne organisms on seeds of barley, corn, oats and wheat was usually accompanied by blighted seedlings and reduced germination.

4. Autoclaved soil consisting of equal parts of soil and sand provided a satisfactory substratum in which seedling blights of barley, oats and wheat were readily determined.

5. Treatment of infected seeds of barley, corn, oats and wheat with organic mercury compounds, practically controlled seedling blights in the laboratory and, with a few exceptions, resulted in significant increases in both field and laboratory germination. Samples benefited most in the laboratory by treatment, responded similarly in the field. The effect of seed treatment on flax seed germination was similar to that on the small grains in so far as the number of normal seedlings was concerned, but no record of the seed-borne organisms was made.

6. Dilution of 5 percent ethyl mercury phosphate to a 1 percent dust by the addition of French talc, button dust or gypsum provided a satisfactory laboratory dust which may be added in the quantity that will readily adhere to small grain and flax seeds. The effect of the diluted dusts as used in the laboratory was comparable to that in the field. The fillers used as treatments alone were responsible for an increase in the germination and yield of barley but to a less extent than when combined with the mercury compound.

7. The development of such organisms as species of *Alternaria*, *Aspergillus*, *Macrosporium*, *Mucor*, *Penicillium* and *Rhizopus* was practically controlled on seeds tested in blotters by treatment with ethyl mercury phosphate or ethyl mercury chloride.

8. The greater difference in germination between treated and untreated seeds of corn, small grains and flax in the laboratory than in the field may be due to the control of normally saprophytic fungi which probably cause less injury in the field than in autoclaved soil or in blotters.

9. Mercury poisoning when mildly expressed in blotters was not evident in soil tests. Evidence of severe poisoning is readily noticeable in soil tests.

10. Taken as a whole, the difference in yield from treated and untreated seeds of barley, corn and oats was significant in favor of treated seed, the greater increases being obtained from lots infected with seed-borne organisms.

11. Germination of the seeds of barley, corn, flax, oats and wheat was usually less in the field than in the laboratory, but the rank of a given sample in the laboratory was usually maintained in the field. In seasons of deficient rainfall field germination does not give an accurate measure of seed viability. Seed laboratory tests properly conducted are more reliable indices of viability.

12. Detection of seed-borne pathogens and determination of the effect of seed disinfectants on seed germination by laboratory methods constitute two pathological techniques which may be utilized in a seed laboratory. The results of the laboratory tests were reasonably indicative of field response.

Indexing Farmers' Seed Lots for Seed-Borne Organisms and Response To Seed Disinfectants¹

BY R. H. PORTER, W. E. HENDERSHOTT AND G. N. DAVIS²

The determination of purity and viability of seeds has long been the major function of seed laboratories in the United States and other countries. Certain standard techniques have been developed on which rules and recommended procedures for seed analysis have been based. Until recently, as pointed out by the senior author (14, 15,) scant consideration has been given to the importance and significance of organisms carried in or on seeds, although Munn (11) as early as 1919 called the attention of seed analysts to their responsibility concerning the pathological condition of seeds. Since 1930 the large number of samples of field crop seeds received annually by the seed laboratory at Iowa State College has afforded an unusual opportunity to utilize certain phytopathological techniques in the determination of seeding value.

One of the important techniques is that of detecting the presence of seed-borne pathogens on crop seeds and determining the effect of such pathogens on germination in the laboratory and field. A preliminary report of investigations in 1932 was given by Porter (12) in 1935, in which the effect of *Gibberella saubinetii* (Mont.) Sacc. and *Helminthosporium sativum* P. K. and B. on the germination of barley in the laboratory was shown to be reasonably indicative of that in the field.

A second pathological technique which may be readily utilized in a laboratory is that of seed disinfection. The development and use of organic mercury compounds for seed treatment as described by Melhus et al (10), Holbert et al (7) and Raleigh (16) have opened new possibilities for studies with seed disinfectants; yet no systematic attempt has been made until recently by seed laboratories to compare the effect of seed disinfectants on seeds in laboratory tests with the effects in the field. In 1935 and 1936, Porter (12, 13) gave a brief summary of the effect of seed disinfectants on laboratory and field germination of barley, corn, flax, oats, peas and wheat. He showed that dust fungicides

¹Projects 390 and 427 of the Iowa Agricultural Experiment Station.

²The authors are indebted to Dr. C. S. Reddy for suggestions concerning dilution of ethyl mercury phosphate and to Prof. G. W. Snedecor for advice and assistance with the statistical aspects of the investigation.

properly used have a definite place in seed laboratory technique in that their effect in the laboratory on germination and their control of seedling blight were indicative of similar effects in the field. The results obtained in the preliminary trials suggested the possibility of indexing seed disinfectants as to their value for field use.

The value of seed disinfectants is determined not only by their effect on germination and disease control but on yield as well. Koehler (9) has shown the extent to which certain seed treatments increased the yield of small grains in Illinois, Burnett and Reddy (2) reported on the effect of treating varieties of barley, and Reddy and Burnett (17) reported increases in yield from treating flax.

Inasmuch as the ultimate value of determining the presence and effect of seed borne organisms and of seed disinfectant on seed germination is the extent to which laboratory response is a measure of that in the field, it becomes necessary to start with a representative sample of a given lot, determine the organisms present, observe the effect of such organisms on seed germination, compare the development of normal seedlings from treated and untreated seeds in the laboratory and field and finally determine the relative percentages of diseased plants and the yield of grain produced by treated and untreated seed. The accumulation of such information by a seed laboratory should make it possible to give farmers some indication of the value of a given lot of seed, on the basis of a laboratory test. Crozier (4) has recently suggested that seed laboratories have an opportunity to aid in the promotion of disease control methods.

The data presented in this paper were obtained in the years 1932-36 from a laboratory and field study of seed samples of barley, corn, flax, oats and wheat. The majority of samples used was supplied by farmers and represented their seed stock, hence information concerning such samples is pertinent in that it should indicate, first, the pathological condition of seeds planted by farmers and, second, the effect of seed treatment on farmers' lots of seed when planted in the field. The major points covered in this bulletin are 1. laboratory detection of seed-borne pathogens, 2. germination of treated and untreated seed in the laboratory and field and 3. yields from treated and untreated seed.

MATERIALS AND METHODS

With the exception of five varieties of barley used in 1933, all seed samples included were obtained from farmers and represented lots intended for field planting. Practically all

samples were tested in the seed laboratory on top of moist blotters to determine the pathogenic condition of the seed. No fewer than 200 seeds from each sample were used. The laboratory temperatures used were 20°C. for barley, flax, oats and wheat and 24-27°C. for corn. The organisms recorded for corn were the dry rot fungi including *Basisporium gallarum* Moll., *Diplodia zeae* (Schw.) Lev., *Fusarium* spp. and *Gibberella saubinetii* (Mont.) Sacc. Samples of barley, oats and wheat were examined for the presence of *Gibberella saubinetii*, *Fusarium* spp. and *Helminthosporium sativum* P. K. & B. or other species. Known symptoms of the several fungi were relied upon largely for a determination of their presence, although examination of doubtful specimens was made microscopically. Symptoms of dry rot diseases of corn have been adequately described by Durrell (5, 6) and Koehler and Holbert (8). Symptoms of *H. sativum*, *Gibberella saubinetii* and species of *Fusarium* on barley in seed laboratory tests have been described recently by Porter (12) and the symptoms on oats and wheat are similar.

Seed treatments, except with 5 percent ethyl mercury phosphate at the rate of $\frac{1}{2}$ ounce per bushel, were applied by placing the seed and a slight excess of the dust in a bottle which was rotated on a treating machine described by Porter (13). The excess dust was screened off by shaking the seed in a tea strainer. Actual application of the 5 percent dust was made by the use of the rotating machine, but the quantity of dust to add was based on the weight of grain in the sample, the ratio being $\frac{1}{2}$ ounce of the dust per bushel of grain. Treated seeds of barley, flax, oats and wheat were kept in envelopes or sacks in the laboratory at least 24 hours before planting in either the germinator or the field.

Both treated and untreated samples of barley, flax, oats and wheat, were planted in copper boxes 6x12x1 $\frac{1}{2}$ inches with autoclaved soil and sand, in equal proportions, as the substrate. From each sub-sample 200 seeds were planted, the soil carefully watered, the boxes placed at 20°C until the seedlings were about 2 inches high, then placed on top of a laboratory table and held until the plants were 5 or 6 inches high. The percentages of normal, weak and blighted seedlings were recorded.

Field plantings for stand counts of small grains and flax were made in 5 foot rows, 100 seeds per row. Each sample was randomized with five replications in a Latin square or other arrangement. The number of seedlings which emerged in each row was counted and recorded. Field plantings for yield determinations were made in rows 15, 16, 17 and 20 feet long for oats, wheat, flax and barley, respectively

(except as noted later). Oat plantings were made in pairs of 15-foot rows making a 30-foot row unit and all plantings included no fewer than five nor more than 10 replications. Rates of sowing were 28, 96, 90 and 96 pounds per acre of flax, oats, wheat and barley, respectively. The corn plots were arranged so that each sample per replicate had two 12-hill rows, all samples were randomized and replicated either five or more times. Both stand and yield determinations of corn were obtained from the same plot. Each row of small grain or flax was harvested by hand, the bundle heads covered with a paper sack, tied, the bundles shocked and later threshed separately. The yield was computed by multiplying the weight of grain per row in grams by .1 which gave bushels per acre. Statistical calculations for significance were made by analysis of variance, the chi-square test and the "t" test, each being employed when most applicable. Snedecor (18, 19) has discussed the application of statistical methods to biological data.

VARIETIES OF CROPS USED

The varieties of field crops used in the experiments reported in this paper were not known in every case. In the 1933 trials five varieties of barley, as listed in table 2, were used. No record is available of all the varieties of oats, wheat and flax used in the 1933 trials. The corn samples planted in 1933 were remnants of entries in the state yield contest and represented several hybrids and open-pollinated varieties. In the 1935 and 1936 tests the list of varieties was not complete for each crop, but since most of the varieties are represented in the 1934 tests, repetition of names for 1935 and 1936 is unnecessary.

In 1934 the source of each sample of seed used in all the tests made that year was known, but the variety of some samples was not known. The different varieties of barley, oats, flax and corn represented in the 1934 trials are as follows:

<i>Barley</i>	<i>Oats</i>	<i>Flax</i>	<i>Corn</i>
Colsess	D-67	Bison	Hybrid 931
Hoboken	Gopher	Red wing	" 942
Glabron	Green Russian	<i>Corn</i>	" 942
Manchuria	Iowa 103	Black's Y. D.	(2nd year)
Minsturdi	Iowa 105	Golden King	Iodent
O. A. C. 21	Iowa 444	Hybrid A	K x KR
Oderbrucker	Iogold	" 6	K x IDT
Spartan	Iogren	" 306	Kossuth Reliance
Trebi	Iowar	" 309	Krug
Velvet	Kanota	" 311	McCulloch Y. D.
(17 sources)	Kherson	" 323	Murdock

Barley	Oats	Corn	Corn
Wis. 37	Rainbow	Hybrid 355	Reid Y. D.
Wis. 38			Steen Y. D.
			Wimples Y. D.

In the corn plot planted in 1934 using three dusts (see table 19) the varieties by number are given below:

- | | |
|---------------|------------------|
| 1. Reid Y. D. | 5. Reid Y. D. |
| 2. Hybrid 931 | 6. Black's Y. D. |
| 3. Iodent | 7. Reid Y. D. |
| 4. Iodent | 8. Krug |

The data obtained from all the experiments are presented, analyzed and discussed by crops for the years covered by these investigations.

TRIALS WITH BARLEY

In a recent paper (12) the senior author presented some summarized data obtained from laboratory and field studies in 1933 with treated and untreated barley seed. A portion of the detailed data is given here to 1. show the method of statistical analysis employed and 2. compare the field and laboratory germinations with yields. In addition results obtained in 1934, 1935 and 1936 are included.

The season of 1932 was exceptionally favorable for the development of scab in barley, wheat, oats and rye. Samples of barley received by the seed laboratory in August and September, 1932, indicated that the degree of infection with *Gibberella saubinetii* and species of *Fusarium* was unusually high and that the fungi had penetrated so far into the embryo tissues as to cause either dead seeds or weak seedlings. Preliminary trials with seed disinfectants in the laboratory indicated that seedling blight could be materially reduced by treatment.

RESULTS IN 1933

FARMERS' SEED SAMPLES

In the winter of 1932-33 seed from 20 farmer lots received for analysis was selected at random for laboratory and field study. Each sample was divided into equal parts, one part treated with New Improved Ceresan at the rate of $\frac{1}{2}$ ounce per bushel, and the other left without treatment. In the laboratory the percentage of seed infected with *Gibberella saubinetii* and *Helminthosporium sativum* was determined and the percentages of normal and blighted seedlings which developed in soil were recorded. The data showing the mean percentage of each sample are given in table 1.

The data show that 1. treated seed gave a higher percentage germination than untreated seed with 18 out of

TABLE 1. LABORATORY AND FIELD GERMINATION OF FARMERS' SEED BARLEY SAMPLES. 1933. AMES, IOWA.

Samples no.	Laboratory soil, percent				Blotters		Field germination, per- cent		
	Treated		Check				Treated	Check	Difference
	Normal	Seedling blight	Normal	Seedling blight	G. S.	H. S.			
1	78.5	0	57.0	13.0	19.0	6.0	72.6	44.8	27.8
2	92.0	0	78.5	12.0	12.0	2.0	81.4	60.8	20.6
3	67.5	0	59.0	3.5	36.5	3.5	64.6	54.2	10.4
4	78.0	0	71.0	4.0	7.5	1.5	69.2	64.0	5.2
5	96.0	0	84.0	-----	1.0	26.5	90.0	82.4	7.6
6	89.0	0	90.5	4.0	10.5	2.5	84.6	80.0	4.6
7	87.5	0	87.5	3.0	8.0	2.0	88.2	84.4	3.8
8	83.5	0	88.5	1.5	1.0	9.5	83.0	73.4	9.6
9	87.0	0	84.5	5.0	5.0	9.5	79.0	72.6	6.4
10	85.5	0	77.0	13.0	11.0	7.0	76.6	70.0	6.6
11	88.5	0	79.0	12.0	11.0	12.5	81.0	62.2	18.8
12	92.5	0	86.5	1.0	12.5	8.0	82.8	78.6	4.2
13	87.5	0	85.0	-----	2.0	-----	83.2	74.8	8.4
14	94.5	0	87.5	4.5	4.5	-----	81.6	75.6	6.0
15	92.5	0	73.0	15.5	12.5	-----	86.6	60.0	26.6
16	87.0	0	76.5	4.5	16.0	-----	83.8	74.2	9.6
17	90.0	0	85.5	6.0	6.5	-----	81.6	72.2	9.4
18	89.0	0	80.0	2.0	3.0	-----	80.5	75.8	4.7
19	87.0	0	81.0	8.0	11.0	-----	87.6	78.0	9.6
20	81.0	0	75.5	7.0	9.5	-----	83.8	73.4	10.4
Mean	87.2	0	79.4	5.5	10.0	4.5	81.1	70.6	10.5

G.S.—*Gibberella saubinetii*H.S.—*Helminthosporium sativum*

20 samples in the laboratory and with all samples in the field, and 2. the treatment controlled seedling blight in laboratory soil. *Gibberella saubinetii* was present on the seed of all samples, and *Helminthosporium sativum* was found on the seed of 12 samples. Samples with a high percentage of seed infected with the scab organisms showed a high percentage of either seedling blight or dead seed.

Analysis of variance for the data on germination in both laboratory soil and field indicated highly significant differences in favor of the treatment.

A comparison of field and laboratory germination is of interest in that for the most part samples which germinated high in the laboratory maintained the same relative rank in the field germination. Furthermore, the mean germinations of treated and untreated seed in the laboratory were about equally above the respective field results, or stated in another way, benefits to germination from seed treatment as measured in the laboratory were indicative of field response.

SEED FROM FIVE STANDARD VARIETIES

In the winter of 1932 a supply of seed of the barley varieties Colseess, Glabron, Minsturdi, Spartan and Velvet was

obtained from the Agronomy Farm, Ames, Iowa. The preliminary tests on blotters indicated such severe infection with scab organisms that the lots afforded an opportunity to study further the possibilities of determining methods for detecting seedling blight and of comparing laboratory and field germination of treated and untreated seed.

In laboratory practice it is difficult to apply ethyl mercury phosphate to small samples of seed at the rate of $\frac{1}{2}$ ounce per bushel. To simplify laboratory procedure and make seed treatment of small grains applicable to laboratory practice, dilutions of 5 percent ethyl mercury phosphate to a 1 percent dust were made using three different fillers. Dilution with talc was first used by Porter (12) in experiments conducted in 1933 and reported in 1935. The purpose of the experiment was to determine if a 1 percent dust applied at the rate which will adhere readily to seeds would give results comparable to a 5 percent dust applied at the rate of $\frac{1}{2}$ ounce per bushel. Each filler was also used separately to determine any harmful or beneficial effects of the fillers without the disinfectant.

The experiment as outlined consisted of nine different sub-samples of seed from each variety treated as follows:

1. Untreated check.
2. Ethyl mercury chloride 2 percent, 3 ounces per bushel.
3. Pure talc filler, 3 ounces per bushel.
4. One part 5 percent ethyl mercury phosphate and 4 parts talc applied at rate of 3 ounces per bushel.
5. Pure gypsum filler, 3 ounces per bushel.
6. One part 5 percent ethyl mercury phosphate and 4 parts gypsum, 3 ounces per bushel.
7. Button dust filler, 3 ounces per bushel.
8. One part 5 percent ethyl mercury phosphate and 4 parts button dust, 3 ounces per bushel.
9. Five-percent ethyl mercury phosphate, $\frac{1}{2}$ ounce per bushel.

Laboratory plantings of all sub-samples were made in soil in copper boxes using 200 seed from each sub-sample. At the conclusion of the test the percentages of normal, weak and blighted seedlings were recorded. Treatments 3, 5 and 7 were in reality fillers, and treatments 2, 4, 6, 8 and 9 each contained an organic mercury dust. To compare the effect of the three fillers against the check, the five mercury dusts against the check and the fillers against the mercury dusts, the total number of strong sprouts was obtained for each of the three sets, and three comparisons were made by the chi-square test for homogeneity.

Table 2 shows that in laboratory soil there were significant differences in germination for all varieties between the mercury treated sub-samples and the checks, between the filler treated sub-samples and the checks and between the mercury treated and filler treated sub-samples except for Glabron. The effect of the filler treatments, which had been assumed to be inert in their action, is rather striking, in fact, for the varieties Glabron and Velvet the effect of the three fillers approaches closely that of the organic mercury treatments.

The more complete data for laboratory germination in soil are given in table 3, from which it may be noted that the mercury treatments practically controlled seedling blight.

For one field planting, five 100-seed lots were removed from each sub-sample 1, 2, 4, 6 and 9, each lot planted separately in a 5-foot row and covered with 1 to 2 inches of soil. The Latin square method of planting was used. Stand counts were made in each row when the seedlings were about 3 or 4 inches high and before stooling had occurred. A second field planting was made according to a Latin square arrangement with nine replications for each of the nine sub-samples of each variety. The rows were 16 feet

TABLE 2. RESULTS OF LABORATORY SOIL GERMINATION OF FIVE VARIETIES OF BARLEY SEED

Variety	Treatment	No. of seeds*	No. of sprouts	$\bar{X}$	P	Average percent germination
Colsess	Mercury dust	1300	1136			87.4
	None	300	160	180.0	< .01	53.3
	Mercury dust	1300	1136			87.4
	Filler	600	431	68.7	< .01	71.8
	Filler	600	431			71.8
Glabron	None	300	160	30.4	< .01	53.3
	Mercury dust	1300	1156			88.9
	None	300	231	20.4	< .01	77.0
	Mercury dust	1300	1156			88.9
	Filler	600	516	1.57	.20	86.0
Minsturdi	Filler	600	516			86.0
	None	300	231	14.38	< .01	77.0
	Mercury dust	1300	1116			85.8
	None	300	198	66.3	< .01	66.0
	Mercury dust	1300	1116			85.8
Spartan	Filler	600	465	20.47	< .01	77.5
	Filler	600	465			77.5
	None	300	198	13.64	< .01	66.0
	Mercury dust	1300	959			73.8
	None	300	128	108.2	< .01	42.7
Velvet	Mercury dust	1300	959			73.8
	Filler	600	358	38.38	< .01	59.7
	Filler	600	358			59.7
	None	300	128	23.27	< .01	42.7
	Mercury dust	1300	1174			90.3
	None	300	216	71.68	< .01	72.0
	Mercury dust	1300	1174			90.3
	Filler	600	510	11.48	< .01	85.0
	Filler	600	510			85.0
	None	300	216	21.67	< .01	72.0

* Three treatments were made in triplicate, two in duplicate. Checks were in triplicate and the three filler treatments were in duplicate.

long, and 15 grams of seed were planted per row. The grain from each row was harvested and threshed separately and the yield determined in grams.

Table 3 shows the field germination and yield of each variety of the untreated and four mercury treated subsamples, each with five and nine replications, respectively. Analysis of variance of the data showed that the treatment as a whole gave highly significant increases in stand for all varieties except Glabron, and even for Glabron the increase was significant.

The yield data obtained from the five varieties each treated with five mercury dusts and three fillers, as shown in table 3, were subjected to analysis of variance which showed that the differences in yield in favor of treated seed as a whole were highly significant for varieties Minsturdi and Spartan, nearly significant for varieties Colseess and Glabron and slightly below significance for variety Velvet. The data are interesting, because, of the eight treatments three are filler dusts. By separation of the data in table 3 for bushels per acre into groups the following results are obtained:

Variety	Yield, bushels per acre		
	Check	Mean of five mercury treatments	Mean of three fillers
Colseess	13.8	17.4	14.4
Glabron	28.0	28.4	28.4
Minsturdi	20.2	29.0	23.5
Spartan	15.4	26.4	22.2
Velvet	22.8	27.8	24.4

From the above data it is evident, that with the exception of Glabron, the mercury dusts were responsible for greater increases in yield of barley than were the fillers. The differences due to treatment with mercury dusts are highly significant with the exception of Glabron. A second point of interest is that differences in yield in favor of treatment with three fillers are significant for varieties Minsturdi, Spartan and Velvet. The effect of fillers is of interest in that not only were yields increased but germination as well. Apparently some of the supposedly inert fillers have some disinfecting value or supply a needed food element. Bressman (1) has shown that gypsum increases the percentage of germination and the yield of corn.

RESULTS IN 1934

In the spring of 1934, seed from 75 samples of barley was obtained from farmers and planted in three plots, 25 samples per plot, one each in Story, Grundy and Pocahontas

TABLE 3. TABLE OF AVERAGES; GERMINATION AND YIELD OF FIVE VARIETIES OF BARLEY, TREATED AND UNTREATED. 1933.

Treatment	Laboratory averages, percent				Field averages	
	Strong	Weak	Dead	Seedling blight	Germination percentage	Yield bu. per acre
COLSESS A						
1	53.3	22	24.7	22	54.4	13.8
2	89	3.5	7.5	0	81.8	17.6
3	70.5	15.5	14	13.5		14.5
4	86.7	2.5	11	0.3	77.4	18.9
5	72.5	12.5	15	14		14.8
6	82.5	2	15	0	57.0	17.3
7	73.5	14.5	12	16		14.0
8	88.3	2	9.7	0.3		15.4
9	88.7	0.7	9.7	1	80.0	18.0
GLABRON B						
1	77	9.7	13.3	8.3	73.4	28.0
2	88	1.5	10.5	0	80.8	29.9
3	85.5	6.5	8	5		29.2
4	90.7	2.3	7	0	80.0	27.3
5	87.5	3.5	9	3.5		30.9
6	87	2.5	10.5	0	78.0	28.2
7	85	6	9	2		25.2
8	92	1	7	0		27.8
9	86	3.3	10.7	1.7	77.2	28.9
MINSTURDI C						
1	66	19.7	14.3	18.3	59.8	20.2
2	87	0.5	12.5	0	87.0	30.1
3	74.5	9	16.5	9.5		25.1
4	86.7	1.7	11.7	0.7	81.2	27.9
5	77	11	12	9.5		22.4
6	83	3	14	0	83.4	29.0
7	81	8.5	10.5	8.5		22.6
8	85.7	2.3	12	1		31.6
9	86.3	3.7	10	2.7	80.0	26.4
SPARTAN D						
1	42.7	19	38.3	18.7	46.4	15.4
2	75	1	24	0	63.2	25.9
3	55	14	31	14		22.2
4	65.3	5.3	29.3	1	63.4	26.6
5	57	12	31	14		21.9
6	70	4	26	0	59.4	25.4
7	67	9.5	23.3	9.5		22.4
8	63	3	34	1.7		27.8
9	71.3	1.7	27	0	60.6	26.4
VELVET E						
1	72	19.7	8.3	21.7	60.2	22.8
2	91	2.5	6.5	0.5	85.0	27.0
3	84.5	8	7.5	7		24.5
4	89.3	3.3	7.3	1.3	80.0	22.8
5	87.5	3.5	9	2.5		24.2
6	91.5	1.5	7	0	81.8	27.2
7	83	7	10	7		24.5
8	88.7	3.8	7.7	1.3		27.9
9	91.7	1	7.3	0	81.4	23.9

Note: Laboratory tests of treatments Nos. 2, 3, 5, 6 and 7 were made in duplicate. Laboratory tests of treatments Nos. 1, 4, 8 and 9 were made in triplicate. Replications in field tests were five and nine for germination and yield respectively.

counties. Each lot was divided into two portions, one treated with New Improved Ceresan, the other untreated. Seed from both treated and untreated portions was tested in the laboratory on blotters and in soil and also planted in the

field at the rate of 20 grams per 20-foot row and replicated 10 times. Lack of rain throughout the summer accompanied by high temperatures greatly reduced the yield; in fact, the yields were so low in plot 2, Grundy, and Plot 3, Pocahontas, that the data were not tabulated.

The laboratory germinations in soil, the field stand and yield as obtained are shown in table 4. Analysis of variance showed the difference in yield in plot 1 in favor of treated seed to be significant as a whole, 20 of the 25 samples when treated yielding more than when untreated.

The data on germination in the laboratory and field for all plots were analyzed by the "t" test, not for each sample but as a whole. The summary of the calculations showing significance or non-significance are given in table 5, from which it is evident that in only two comparisons, plot 3, spring planting, and plot 4, are the differences of no significance. All other differences were significant in favor of treated seed.

The difference in field germination of barley in the fall and spring plantings of 1934 is worthy of mention. Seed for field stand counts was planted in 5-foot rows, 100 seed per row, with five replications. The furrows were opened with a plow, the seed planted and covered with a rake. Higher germinations in the fall were due to more available moisture, and the germinations in the spring illustrate the danger of placing too much emphasis on a field test as a measure of germination. The seed planted for yield data in the spring was drilled with a small hand drill equipped with an endless belt, a method which disturbed the soil slightly and conserved moisture. The plot was rolled as soon as planted. The germination in the 20-foot rows planted for yield data was far greater than in the 5-foot rows from which stand data were obtained.

TABLE 4. GERMINATION AND YIELD OF TREATED AND UNTREATED BARLEY SEED.

Plot	Year	No. samples	Treated					Check				
			Mean germination, percent					Mean germination, percent				
			Laboratory	Seedling blight	Field		Mean yield	Laboratory	Seedling blight	Field		Yield
					Spring	Fall				Spring	Fall	
1	1934	25	88.6	0.10	37.4	84.6	8.6	77.8	4.0	34.0	80.8	7.9
2	1934	25	89.9	0.02	64.6	82.4		77.6	6.2	61.2	78.4	
3	1934	25	91.1	0.40	56.3	86.0		85.9	4.8	56.0	81.5	
4	1935	6			78.2					76.5		
5	1936	20			62.2			73.3	15.9	59.5		

RESULTS IN 1935 AND 1936

Seed from six lots of barley was planted in the field in 1935, each sub-sample treated and untreated, with five replications. Stand counts were made soon after emergence, and the summarized data obtained are shown in table 4. Of the six lots used only one was not benefited by treatment, but the difference between the means was small. The chi-square test applied to the data indicated no significant difference for the treatment as a whole. The seed used was grown in 1934 when little or no scab developed, and conditions for germination in the spring of 1935 were exceptionally favorable.

Yield tests with treated and untreated barley in 1935 were made with 10 seed lots, several of which were from the 1932 and 1933 crops. The data are shown in table 6. The treatment with New Improved Ceresan as a whole was of no benefit either to the germination or yield, but it did control covered smut in that the average number of smutted heads per row of treated and untreated seed was 0.5 and 7.9, respectively. The failure of the Ceresan treatment to increase the yield in 1935 is probably due to several factors: 1. The rate of seeding (2 bushels per acre) may have been more than necessary, which, with the favorable conditions for germination and subsequent growth, gave an adequate stand from the untreated seed; 2. a severe epiphytotic of scab occurred in late June which resulted in such uniform infection of the heads that any possible small differences may have been over-balanced by the general reduction in yield; 3. late sowing date which was April 20 and 4. the age of the seed used in the tests. Shands (20) has shown that the scab organism undergoes a rapid decline in viability in barley 9 to 12 months after harvest, in which case seed treatment of 2-year old seed would result in little or no benefit.

The summarized data obtained with 20 lots of barley in 1936 are shown in table 4. The lots were grown in 1935 and in general were somewhat infected with the scab organisms, the average percentage being 15.9. Field germination of treated and untreated seed, five replications of each, gave 62.2 percent for the treated and 59.5 percent for the untreated. Fifteen of the twenty lots were benefited by treatment. Field germination for untreated seed was considerably less than laboratory germination, because of the lack of adequate moisture in the spring of 1936.

TRIALS WITH OTHER SEED DISINFECTANTS

The weather conditions in 1935 were so favorable for the development of head blight of barley caused by the

TABLE 5. SUMMARY OF STATISTICAL ANALYSES OF BARLEY TREATMENT DATA BY "T" TEST.

Plot no.	Year	Laboratory germination			Field germination			
		Number of samples		"t" test	Spring		Fall	
		Tested	Increased		Number increased	"t" test	Number increased	"t" test
1	1934	25	20	HS	19	HS	18	HS
2	1934	25	25	HS	18	HS	21	HS
3	1934	25	21	HS	18	NS	19	HS
4	1935	6	No planting		18	NS	No planting	
5	1936	20	"		16	HS	"	

S—Significant; NS—Not significant; HS—Highly significant.

TABLE 6. YIELD, AMOUNT OF DISEASE AND GERMINATION OF TREATED AND UNTREATED BARLEY SEED, 1935.*

No.	Sample	Variety	Check			Treated	
			Yield bushels per acre	Laboratory germination percent	Percent scab	New Improved Ceresan	
						Yield bushels per acre	Laboratory germination percent
1	Not given		17.7	91.0	2.5	18.3	94.5
2	"	"	20.3	83.5	5.0	17.5	91.0
3	"	"	15.1	86.5	3.5	20.9	86.5
4	Wis. 38		22.5	79.5	3.5	22.0	80.5
5	Not given		19.7	73.5	3.5	18.4	69.0
6	Manchuria		18.0	88.5	3.0	18.8	92.0
7	Not given		18.1	96.5	2.0	20.7	97.5
8	"	"	17.6	91.0	3.0	17.7	90.0
9	Velvet		21.2	93.5	3.5	18.6	91.5
10	1932 crop						
	Not given		22.0	82.0	11.0	19.5	81.0
	1933 crop						
	Mean		19.2	87.0	4.5	19.2	87.3

* Yield test plot planted April 20.

scab organisms that infected seed lots were treated with formifume, Special Copper Compound KB and Barbak C in addition to ethyl mercury phosphate. Plantings were made in soil using the same method as described for the 1933 tests. The results showed that ethyl mercury phosphate controlled seedling blight and significantly increased the number of normal seedlings as compared with those produced by untreated seed. None of the other compounds were effective in increasing the germination or in decreasing the percentage of seedling blight in comparison with untreated seed. Trials were made with infected wheat seed and the results were similar to those obtained with barley. The limited data obtained with seed disinfectants suggest that laboratory tests of seed fungicides can be used

as an indicator of their field value for the control of seedling blight. In certain seasons the control of seedling blights is an important factor in contributing to increases in yield, hence a disinfectant which not only controls certain systemic seed-borne pathogens but increases the stand as well has considerable merit.

RATE OF SEEDING IN RELATION TO SEED TREATMENT

The increase in stand obtained by seed treatment of barley in 1933 suggested that a reduced rate of seeding with treated seed might 1. give as high a yield as a heavier rate and 2. result in a greater difference in yield between treated and untreated seed than the usual rate. In 1934 five lots of barley were prepared and planted at 6, 7 and 8 pecks per acre, respectively, using both treated and untreated seed in each of five replications. The results of this study are shown in table 7. Calculation of chi-squares by comparing the total number of plants produced by treated and untreated seed in both laboratory and field indicated a highly significant difference in favor of seed treatment.

Analysis of variance of the yield data showed that increases due to treatment as a whole were highly significant for all except the heavy rate of seeding. Higher yields for both treated and untreated seed were obtained from the light rate of 6 pecks per acre (15 grams per 20 foot row). The heavy rate (8 pecks) gave a significantly lower yield, and the increase due to the treatment was less marked. The data are not conclusive in that only 1 year, and that a year of subnormal yields, is represented, however, they are suggestive of possible value from rates of seeding below average.

DISCUSSION OF BARLEY TRIALS

Data obtained from laboratory and field tests with 129 seed lots of barley in the years 1932-36 show that 1. the presence of certain pathogenic organisms, namely, Gib-

TABLE 7. GERMINATION AND YIELD OF TREATED AND UNTREATED BARLEY SOWN AT THREE DIFFERENT RATES PER ACRE.

Sample	Germination						Yield											
	Laboratory (soil)		Field				Planted 6 pecks per acre			Planted 7 pecks per acre			Planted 8 pecks per acre					
			Spring		Fall													
	Treated	Check	Tr.	Ck.	Tr.	Ck.	Tr.	Ck.	Diff.	Tr.	Ck.	Diff.	Tr.	Ck.	Diff.			
1. Wis. 38.....	89.0	88.5	39.2	33.2	88.2	82.4	12.3	10.3	2.0	10.6	9.5	1.1	13.0	11.8	1.2			
2. Spartan.....	76.0	62.5	28.6	25.0	67.6	56.6	11.6	9.4	2.2	10.7	10.4	.3	5.0	4.4	.6			
3. Minsturdi.....	89.0	60.0	48.2	36.0	83.2	67.0	11.6	11.1	.5	11.2	8.2	3.0	3.0	2.8	.2			
4. Glabron.....	86.5	65.0	24.8	33.0	83.4	73.8	9.8	7.3	2.5	10.3	9.1	1.2	8.7	8.8	-.1			
5. Velvet.....	98.5	85.0	41.6	37.8	92.8	91.4	12.7	10.7	2.0	11.8	10.4	1.4	8.2	8.0	.2			
Mean.....	87.8	72.2	36.5	33.0	83.0	74.0	11.6	9.8	1.8	10.9	9.5	1.4	7.6	7.4	.4			

Yield test plot planted April 10, 1934.

berella saubinetii and related species of *Fusarium* and *Helminthosporium sativum*, may be detected by germinating the seeds on top of moist blotters, 2. both types of organisms interfere with normal germination causing weak seedlings and dead seeds, 3. the scab organisms produce definite detectable symptoms of seedling blight when the plants are grown in autoclaved soil and sand, 4. 2 percent ethyl mercury chloride, 5 percent ethyl mercury phosphate and dilutions of 5 percent ethyl mercury phosphate to a 1-percent dust, using either gypsum, French talc or button dust as the diluent, applied to infected barley seeds controlled seedling blight in the laboratory, increased the number of normal seedlings and produced a similar increase in field stand, and (5) the treatments used resulted in a significant increase in yield in 1933 and 1934. Christensen in 1936 (3) stated that both Ceresan and New Improved Ceresan decreased seedling injury with a consequent material increase in plant vigor of naturally infected barley seed.

The data further show that 1. laboratory germination in soil was usually higher than in the field, 2. samples which gave high germination in the laboratory maintained their relative rank in field tests and 3. lots increased in germination by seed treatment in the laboratory responded similarly in the field although the percentage increase was less.

In the routine of reading the tests one observation worthy of mention is that organisms normally considered saprophytes, including species of *Alternaria*, *Aspergillus*, *Macrosporium*, *Mucor*, *Penicillium* and *Rhizopus* were effectively controlled in blotter tests by treatment with mercury compounds. Such an effect in blotter tests may be reflected in autoclaved soil where conditions for the spread of such organisms on untreated seed would be exceptionally favorable as a result of no competition from other soil organisms. It is suggested that the larger increase in germination of treated seed in the laboratory than in the field may be explained by the control under artificial conditions of saprophytes which in field soils are less able to interfere with seed germination. Further study of this phase is being continued.

A second observation is that a slight excess of volatile mercury compounds caused mercury poisoning where treated seeds were tested on blotters, whereas little or no effect was noted in soil tests. Excessive treatments, especially with 5-percent ethyl mercury phosphate, caused mercury poisoning in both blotter and soil tests.

In general, all varieties responded favorably to seed treatment, some more than others. Results obtained with Velvet using 17 different farmers' samples as well as the strain

which has been grown by the Agronomy Farm indicated that seed treatment increased the germination of diseased lots in laboratory and field and was followed by increased yields in 1933 and 1934. In 1935 one lot of Velvet from the 1932 crop did not yield more after seed treatment, probably because of reduced virulence of the scab parasite in the seed and the late planting date. Burnett and Reddy (2) report that increases in barley yields from seed treatment are greater when sown early than when sown late. The same authors further report no increases in yield with treatment of varieties Velvet, Glabron and Manchuria. The 1933 data reported in the present paper show a slight yield increase following treatment of diseased seed of Glabron and a significant increase of Velvet. Additional data obtained in 1934, using three rates of seeding with treated and untreated seed of the varieties Wis. 38, Spartan, Velvet, Minsturdi and Glabron, showed that increases in yield following treatment were greater at the $1\frac{1}{2}$ -bushel per acre rate than at the 2-bushel rate, in fact the increases were significant on all varieties at the low and not significant at the high rate. Since treatment increases the germination of barley seed infected with the scab organisms, it is reasonable to expect that heavier rates of seeding untreated seed are necessary for maximum yields. Any increase in stand above the optimum would be of no benefit, in fact, might reduce the yield in some seasons.

As a result of the experimental work with barley it appears that two pathological techniques, namely, detection of seed-borne pathogens and seed disinfection of barley, are readily applicable to seed laboratory practice and insofar as possible should be adopted as a part of the routine examination of barley seed.

TRIALS WITH OATS

Experiments performed with oats were similar to those described for barley. Laboratory tests were made in duplicate, field stand counts were determined from five replications of each sub-sample of treated and untreated seed, and yields were obtained from 10 replications of 15-foot rows in pairs in 1934 and from five replications of 15-foot rows in 1935. The treatment used unless otherwise specified was New Improved Ceresan, $\frac{1}{2}$ ounce per bushel.

The data for 1933 on 20 samples are given in table 8, from which the following conclusions are evident: 1. The increase in germination of treated over untreated seed in laboratory soil is significant; 2. analysis of variance of the field germination data showed an F value high enough to indicate a significant difference in favor of the treatment

as a whole, but with only 10 of the lots was the difference of high significance; 3. smut control was nearly complete as a result of treatment. Unfortunately no laboratory examinations for the presence of smut on the seed were made.

Data obtained in 1934 are presented in table 9. The location of the plots was as follows: Plot 1, Story County; plot 2, Grundy County; plot 3, Pocahontas County. Laboratory germinations were not obtained for the samples in plots 1 and 3, and no field test was made in the fall for the samples used in plot 3.

A study of the laboratory and field germination was made by means of the "t" test, the results of which are shown in table 10 and are self-explanatory.

The yields were far below normal, yet the differences in yield from treated and untreated seed in favor of the treated lots were highly significant as a whole in all plots.

Additional observations from the 1934 data which deserve mention are: 1. Smut control in all plots was highly successful; 2, the greater yields from treated than untreated seed certainly were not due to smut control alone; 3. the ability of oats to withstand drouth better than barley (compare barley yields of table 9 with oat yields of table 16, same soil) is apparent and 4. the stand and possibly the yield of the oats in all plots in 1934 is in part due to the fact that the grain was all drilled in rows with minimum disturbance

TABLE 8. LABORATORY AND FIELD GERMINATION OF TREATED AND UNTREATED OATS, 1933.

Sample number	Laboratory germination					Field			
	Blotters percentage		Soil, percentage			Germination percentage		Smutted heads per five rows	
	Check		Check		Treated				
	Strong	Scab	Strong	Seedling blight	Strong	Check	Treated	Check	Treated
1	95.5	6.0	95.0		95.5	80.2	86.2	4	0
2	90.0	6.5	94.0		95.5	76.2	84.4	3	0
3	81.0	2.5	80.0		87.0	79.4	80.5	4	2
4	84.5	1.0	96.0		96.0	76.0	75.4	24	0
5	86.5	3.5	73.0	2.0	89.0	77.2	80.8	4	0
6	18.0	7.0	18.0		47.5	1.9	23.0	0	0
7	88.0	5.5	88.0	2.5	93.5	79.2	85.6	9	0
8	79.5	4.0	72.5		88.0	79.6	85.6	6	0
9	84.0	5.0	87.5		90.5	73.4	75.4	20	0
10	89.5	7.0	89.5	3.0	89.5	79.4	79.2	5	0
11	81.5	6.0	73.0		87.0	73.8	84.4	8	0
12	83.0	13.0	85.0	4.0	89.5	79.8	77.4	3	1
13	89.0	6.0	90.5	2.0	94.0	77.2	81.6	3	0
14	63.0	5.5	92.5		97.0	76.8	81.8	5	0
15	80.5	3.0	93.5		93.5	82.2	83.8	2	0
16	87.5	1.5	90.5		93.0	77.2	79.8	9	0
17	63.0	2.5	89.0	1.0	91.5	72.8	80.2	10	0
18	86.0	3.5	85.5	1.0	89.0	75.0	80.2	9	0
19	20.5	26.0	73.5		83.0	71.0	75.8	0	0
20	41.5	1.5	70.5		80.5	77.8	76.8	38	0
Mean	74.0	5.8	81.8	0.8	88.5	73.3	77.9	8.8	.15

TABLE 9. MEAN GERMINATION AND YIELD OF TREATED AND UNTREATED OATS, 1934.

Plot number	Number samples	Treated				Check			
		Mean percentage germination Field		Mean yield bushels per acre	Smutted heads per 10 rows	Mean percentage germination Field		Mean yield bushels per acre	Smutted heads per 10 rows
		Spring	Fall			Spring	Fall		
1	20	10.2	93.6	22.9	.25	10.1	92.2	20.9	123.2
2*	20	61.0	84.0	7.2	.20	55.9	83.4	6.6	50.5
3	20	61.1		26.5		57.7		25.1	20.8

* Germination in laboratory of treated and check was 97.1 and 92.3 respectively.

of the soil at planting time. The short rows 5 feet long used for making stand counts were planted by opening furrows and covering, a method which is undoubtedly responsible for the low stands in the spring. Fall germination was much higher even though the same method of planting was used.

The data obtained by treatment of oats in 1935 and 1936 are given in tables 11 and 12. Yields were increased as a result of treatment with New Improved Ceresan and formaldehyde dust, but the New Improved Ceresan was the more effective dust in the control of smut in 1935 in that the average number of smutted heads per 10 rows was 101.9, 2.3 and 9.6 for untreated, New Improved Ceresan and formaldehyde dust respectively. Field germination was not increased significantly by treatment of 20 samples as a whole in 1936 (see table 12), nevertheless, 14 of the 20 treated samples gave a higher germination than untreated samples. Apparently seed treatment may be responsible for either an increase in percent germination, an increase in yield or both.

TABLE 10. SUMMARY OF STATISTICAL ANALYSES BY "T" TEST, OAT TREATMENTS.

Plot number	Year	Lab. germination			Field germination			
		No. samples		"t" test	Spring		Fall	
		Tested	Increased		No. increased	"t" test	No. increased	"t" test
1	1934	20	13		No planting		13	NS
2	1934	20	18	HS	14	S	14	S
3	1934	20	No planting		13	NS	No planting	

S—Significant; NS—Not significant; HS—Highly significant.

TABLE 11. LABORATORY GERMINATION AND YIELD OF TREATED AND UNTREATED OATS 1935.

Sample	Germination on top of blotters. Untreated		Yield, bushels per acre		
	Strong	% Scab	Check	New Imp. Cer.	Formaldehyde dust
1	96	13	40.6	47.1	38.9
2	98	15	36.8	39.0	39.9
3	97	31	31.9	40.0	34.8
4	97	12	33.0	35.8	32.1
5	92	22	37.1	35.3	32.7
6	100	16	36.8	38.7	35.7
7	97	19	32.7	41.8	42.0
8	97	23	36.6	39.5	40.3
9	98	11	32.5	34.4	37.5
10	98	19	28.3	36.0	39.4
Mean	97	18.1	34.6	38.8	37.3

Yield test plot planted April 16.

DISCUSSION OF OAT TRIALS

Laboratory and field studies with 110 different oat seed samples from farmers' seed lots conducted in the years 1932-36 gave results similar to those obtained with barley, in that the same organisms may be detected on laboratory seed samples; seed treatment of diseased lots with ethyl mercury compounds controlled seedling blight and increased germination in both laboratory and field. With the exception of the extremely dry season of 1934 the laboratory germination was indicative of field performance. Field germination in the fall of 1934 was nearly equal to that in the laboratory and much greater than in the field in the spring. The Ceresan treatments effectively controlled smut

TABLE 12. LABORATORY AND FIELD GERMINATION OF TREATED AND UNTREATED OATS, AMES, IOWA. 1936.

Sample	Percent germination					
	Laboratory			Field		
	Strong	G. S.*	H. S.*	Check	Treated**	Difference
1	87.	0	8	75.6	78.8	3.2
2	87.5	1.0	19.5	72.8	74.8	2.0
3	88.	0	21	75.2	78.0	2.8
4	81.	3	15	67.2	68.0	.8
5	86.		4.0	69.2	73.4	4.2
6	89.		10.0	72.0	76.6	4.6
7	71.			50.0	55.4	5.4
8				15.2	16.4	1.2
9				54.0	60.8	6.8
10				77.2	70.8	-6.4
12				75.8	74.0	-1.2
13	22.	0		25.2	22.0	-3.2
11	98.	0	0	5.4	3.8	-1.2
14	77.	8	11	58.6	59.2	.6
15				79.6	66.6	-13.0
16	85.		6	72.4	73.6	1.2
17	90.5	1.5	5.0	72.2	77.2	5.0
18	82.		11	68.6	65.4	-3.2
19	43.5			31.0	40.6	9.6
20	87.5	2.5		65.4	67.0	1.6
Mean	73.9	1.0	6.9	59.1	60.1	1.0

*H.S.—*Helminthosporium sativum* G.S.—*Gibberella saubinetii*

** 1 percent Ethyl Mercury Phosphate.

and significantly increased the yield in 1934 and 1935. The increases in yield obtained by treatment of 60 farmers' lots in 1934 are somewhat remarkable in that the drouth was one of the most severe on record. The effects of treatment are not explainable entirely on the basis of smut control alone. Unfortunately a detailed laboratory study of the oat samples used in 1934 to determine the degree of infection with pathogens was not made. It seems highly probable that seed-borne and possibly soil organisms were partially controlled by the treatments.

TRIALS WITH WHEAT

The effect of seed disinfectants on the germination of spring wheat in laboratory and field was investigated in 1933 and again in 1936. The data obtained are given in tables 13 and 14.

In 1933 five samples were tested in the laboratory by two methods, namely, on top of blotters and in autoclaved soil. Plantings also were made in the field. The data in table 13 show a significant difference between treated and untreated seed in laboratory soil. Each sample was increased in germination by treatment except No. 5. In the field each sample was significantly increased in stand.

In 1936, 11 samples of wheat, each treated and untreated, were planted in the field with five replications of each. Stand counts were made and summarized. Table 14 shows that: 1. Field germination was somewhat less than laboratory germination, and 2. 8 of the 11 samples treated with New Improved Ceresan and seven treated with Barbak gave an increase in field germination over the untreated. The differences due to treatment were of little or slight significance, however. Failure to obtain a greater difference in favor of seed treatment in 1936 may be due in part to the deficiency of moisture which seriously interfered with normal germination. The response of the replicate samples was exceptionally variable, and conditions for germination were less favorable than in 1933. On the other hand the data indicate that seed treatment is not always highly beneficial to seeds.

The high percentage of scab in sample 10 suggested the possibility of studying the effect of removing light weight grains. A sample was blown in the Holland vertical air blast separator until 41 percent of the kernels by weight were removed, leaving 59 percent in the heavy portion. The two portions were then divided into two sub-samples. One portion of each sub-sample was treated with New Improved Ceresan, the other left untreated. Germination tests

were made in autoclaved soil and on top of blotters. The results are tabulated below:

	Germination (percent)					
	Blotters				Soil	
	Check		Treated		Check	Treated
	Strong	Percent scab	Strong	Percent scab	Strong	Strong
Light portion 41 percent	48	70	55.5	30	48.5	55.5
Heavy portion 59 percent	77	26	83	9	67	86

The above results indicate the possibilities of improving samples of scabby wheat by fanning.

DISCUSSION OF WHEAT TRIALS

Laboratory and field studies were made with 21 samples of farmers' seed stocks of wheat. It was found that *Gibberella saubinetii*, species of *Fusarium* and *Helminthosporium sativum* were commonly present on seed samples of the 1932 and 1935 crops. The symptoms and effect of the scab organisms on germinating wheat were similar to those described for barley. Seedling blight developed readily on untreated lots when planted in soil, whereas blight was practically controlled by seed treatment. Laboratory germination of untreated seed was slightly less than in the field but reasonably indicative of field response. Seed treatment increased the field germination to about the same degree as in the laboratory, thus illustrating the applicability of disease control methods in seed laboratory techniques. An additional laboratory technique which may be comparable to the use of a fanning mill is that of separating light weight scabby wheat grain from that less infected, by

TABLE 13. LABORATORY AND FIELD GERMINATION OF TREATED AND UNTREATED WHEAT, AMES, IOWA. 1933.

Sample	Laboratory, percent germination										Field, percent germination		
	Blotters				Soil								
	Check				Check			Treated					
	Strong	Weak	Dead	Scab	Strong	Weak	S. B.*	Strong	Weak	S. B.*	Check	Treated	Diff.
1	77.0	2.0	21.0	6.5	79.5	5.0	4.5	87.0	2.0	0.5	80.4	87.4	7.0
2	78.0	10.5	11.5	16.0	64.5	4.5	8.5	84.0	1.0	0.0	75.2	85.2	10.0
3	77.0	11.0	12.0	23.0	70.0	4.0	8.5	85.0	3.0	0.0	78.4	85.4	7.0
4	89.5	6.5	4.0	7.5	63.5	8.0	13.0	85.5	2.5	0.0	72.6	83.2	10.6
5	88.5	3.0	8.5	11.5	80.0	6.0	6.5	77.5	4.0	0.5	73.4	83.4	10.0
Mean	82.0	6.6	10.1	12.0	71.5	5.5	8.2	83.8	2.5	0.2	76.0	84.9	8.9

* S. B.—Seedling Blight.

TABLE 14. LABORATORY AND FIELD GERMINATION OF TREATED AND UNTREATED WHEAT. 1936.

Sample	Laboratory			Field					
	Mean percent germination Untreated			Total plants five replications			Mean percent germination		
				Check	New Imp. Ceresan	Barbak C	Check	New Imp. Ceresan	Barbak C
	Strong	Scab	H. S.*						
1	98.5	0.5		394	367	343	73.8	73.4	69.6
2	77.	13.0		324	233	263	64.8	56.6	52.6
3	72.0	19.5	12.5	274	292	291	54.9	58.4	58.2
4	79.5	4.0	9.5	317	351	354	63.4	70.2	70.8
5	78.0	15.0		202	235	239	50.5	58.8	59.8
6	70.0	17.0		247	257	286	49.4	51.4	57.2
7	65.0	32.		234	253	288	46.8	50.6	57.6
8	49.0	33.		209	238	226	41.8	47.6	45.2
9	32.0	20.		278	288	278	55.6	57.6	55.6
10	62.5	48.		241	266	291	48.2	53.2	58.2
11	Not tested			264	252	232	52.8	50.4	46.4
Mean	73.4	20.2	2.2	271	280	281	55.1	57.0	57.3

* H.S.—*Helminthosporium sativum*

means of an airblast separator. Percentage infection of the light weight seeds with the scab pathogens was found to be nearly three times as great as that in the heavy portion, yet treatment of seeds in the heavy portion was more beneficial in laboratory soil than of seeds in the light weight portion, a result probably explainable by fewer dead seeds but more weak seedlings in the heavy portion.

TRIALS WITH FLAX

The response of flax to seed treatment in the laboratory and field was studied in 1933, 1934 and 1936. The data obtained are given in table 15.

In 1933, 20 samples were used representing several varieties including Bison and Redwing. Blotter germinations were higher than in autoclaved soil. Field germination was significantly less than laboratory soil germination. The treatment (New Improved Ceresan) in the laboratory and field gave a significant increase in germination over the

TABLE 15. MEAN PERCENTAGE GERMINATION OF TREATED AND UNTREATED FLAX.

Plot no.	Year	Number samples	Treated			Check		
			Laboratory	Field		Laboratory	Field	
				Spring	Fall		Spring	Fall
1*	1933	20	67.9	54.4		62.7	47.8	
2**	1934	15	60.5	47.3		52.9	47.3	
3	1934	15	63.7		40.4	60.3		40.2
4	1934	15	63.7	17.4	36.3	58.0	17.4	31.9
5	1936	10		35		55.6	30.0	

* Germination in blotters gave a mean of 77.2 percent.

** Yields were 6.89 and 6.26 bushels per acre from treated and untreated seed respectively.

checks as measured by the chi-square test. Of the 20 lots, 18 in the field and 15 in the laboratory were benefited by treatment. The "t" test gave significant and highly significant differences in favor of treatment for laboratory and field, respectively.

In 1934, three plots of 15 samples each were planted, one each in Story, Grundy and Pocahontas counties. Hot winds and dust storms were so severe that seedlings were cut off soon after emergence and only one plot was worth harvesting.

The data in table 15 show the results in plots 2, 3 and 4. For plot 2 the difference in laboratory germination was highly significant in favor of treatment. Fourteen of the lots gave an increase in germination as a result of treatment. In the field, germination was irregular and no difference was noted in the means of the treated and untreated lots. Yields though low are of interest in that every sample was increased to some extent by the treatment, the average being 10.1 percent. Analysis of variance of the yield data showed a significant difference in favor of treated seed.

Germination data were obtained in all plots and yield data in plot 2. In three out of five comparisons, each with 15 lots, the treatment caused an increase in the germination of flax seed. In the laboratory test plot 3 and the fall field test plot 4 the difference in favor of treatment was significant. The difference in laboratory germination plot 4 as a result of treatment was highly significant. The difference in field germination of the samples used in plots 3 and 4 planted in the spring and fall is similar to that of barley and oats referred to earlier in this paper, illustrating again

TABLE 16. FIELD AND LABORATORY GERMINATION OF TREATED AND UNTREATED FLAX. 1936.

Sample	Percentage laboratory check	Field				
		Total plants 5 replications		Percentage germination		
		Check	Treated	Check	Treated	Difference
1	72.0	153	185	30.6	37.0	6.4
2	62.0	148	176	39.6	35.2	5.6
3	90.0	250	269	50.0	53.8	3.8
4	58.5	103	135	20.6	27.0	6.4
5	82.5	215	230	43.0	46.0	3.0
6	29.5	46	86	9.2	17.2	8.0
7	81.0	164	224	32.8	44.8	12.0
8	80.5	230	180	46.0	24.0	-10.0
9	-----	73	120	16.0	24.0	8.0
10	-----	110	184	22.0	36.8	16.8
Mean	69.5	149.2	178.9	29.98	35.78	6.0

the effect of moisture deficiency on field germination and the danger of attempting to measure seed viability entirely by field germination.

Field germination of 10 samples of treated and untreated flax in 1936 is shown in table 16. Comparing the total plants each from treated and untreated seed a chi-square value of 40 is obtained which means a probability much less than .01. The treatment was highly beneficial as a whole, although one treated sample gave a decrease in field stand over the untreated.

DISCUSSION OF FLAX TRIALS

A total of 75 seed samples of flax was subjected to laboratory and field germination using both treated and untreated sub-samples. Laboratory germination was found to be fairly indicative of field performance in that a sample with given rank in the laboratory maintained its relative position in the field, although the difference between the two was greater, in general, than for barley, oats or wheat. Significant increases in germination as determined in the laboratory were usually duplicated in the field tests, although with plot 2 in 1934, no differences were observed in the germination of samples planted in the spring. The germination of the replicates in 1934 was extremely variable because of deficiency of moisture. Conditions for field germination were decidedly unfavorable.

Yield data were obtained only in 1934, and although the yields per acre averaged less than 7 bushels, the treatment increased the yield significantly. This effect may well be a result of early planting, inasmuch as Reddy and Burnett (17) reported higher increases in yield from treated flax when sown early than when sown late.

TRIALS WITH CORN

Experiments to determine the response of hybrid and open-pollinated lots of corn to seed treatment both in the laboratory and field were carried on in 1933, 1934, 1935 and 1936. The samples used in 1933 were seed remnants of entries in the State Corn Yield Contest, all others represented seed stocks either of farmers or producers of hybrid seed corn.

Treatments used were Merko, Semesan Jr., New Improved Semesan Jr., Barbak 111 and an experimental dust. Both stand and yield data were obtained from the same plot or plots each year, except in 1933 and 1936 when the drouth in Story County was so severe that yields were not obtainable and in 1935 no stand counts were made. Data

TABLE 18. GERMINATION AND YIELD OF TREATED AND UNTREATED CORN.

Plot no.	Year	No. samples	Laboratory germ. (means)						Mean yield stand		Mean field		Dust used
			Check			Treated					Percent		
			Percent			Percent			Percent		Percent		
			Strong	Weak	Diseased	Strong	Weak		Check	Treated	Check	Treated	
1	1933	40	90.3	6.7	3.4	92.7	5.0	65.5	66.8	39.9	40.2	Merko	
2	1934	20	91.8	4.8	10.1	97.8	.55	67.1	68.8	57.2	59.5	Sem. Jr.	
3	1934	20	93.0	5.5	11.2	98.6	0.9	67.2	68.3	57.9	61.3	"	
4	1936	25	53.9					30.8	33.0			New Im. Sem. Jr.	

from the same plot in which only one dust was used are given in table 18.

With the exception of four samples in plot 1, 1933, the quality was high, and the percentage of diseased kernels was low. Five replications each of two 12-hill rows were planted and randomized in the plot. Analysis of variance of the data obtained from germination tests showed a highly significant difference in favor of the treatment both in the laboratory and field. The yield difference on the whole, however, was not significant. Undoubtedly the high quality of the seed used was such that germination and subsequent growth of untreated seed was equal to that of treated seed. Furthermore, the growing season was lacking in normal rainfall, yet a beating washing rain occurred soon after planting. Many hills were washed out, leaving an uneven stand which had some effect on yield.

In 1934 two plots of 20 lots each were planted using Semesan Jr. as the treatment. Ten replications of two 12-hill rows of each sample were planted. Data from all plots in 1933 and 1934 are given in table 18, and the detailed data for plot 3 are shown in table 19 in order to illustrate the comparative response of each lot in the laboratory and field. The increase in laboratory germination resulting from treatment is highly significant. Likewise the increase in field germination of treated corn over untreated is highly significant as measured by the "t" test, although the gain resulting from treatment in the field is much less than in the laboratory. The data for plot 2 show results similar to those in plot 3. The effect of seed treatment on the yield of corn in plot 3 is worthy of study in that all lots except No. 6 when treated gave an increase in yield above untreated. Analysis of variance of the yield data in plots 2 and 3 indicated that the increase in yield as a result of treatment was highly significant.

TABLE 19. LABORATORY AND FIELD GERMINATION AND YIELD OF TREATED AND UNTREATED CORN. 1934. PLOT 3.

Sample	Percent laboratory germination					Percent field stand		Yield, bushels per acre		
	Check			Treated		Check	Treated	Check	Treated	Gain
	Strong	Weak	Diseased	Strong	Weak					
1	86	9	39	95	1	63.9	64.1	57.7	61.1	3.4
2	95	5	7	100	0	68.2	69.2	60.5	64.1	3.6
3	90	8	13	100	0	66.1	68.4	64.6	70.4	5.8
4	89	9	5	99	1	66.0	68.2	58.1	63.2	5.1
5	93	7	14	96	3	67.7	69.1	64.5	67.2	2.7
6	91	9	10	97	3	68.7	68.5	66.3	63.9	-2.4
7	97	0	9	98	2	68.7	67.3	58.8	61.6	2.8
8	96	2	9	99	1	68.1	69.4	56.1	60.3	4.2
9	91	8	10	99	0	67.4	69.2	64.6	69.7	3.4
10	98	1	5	99	1	67.6	68.5	57.2	60.6	3.4
11	95	4	5	99	1	68.0	68.4	49.5	53.9	4.4
12	90	7	9	99	1	66.7	68.5	55.6	59.4	3.8
13	89	10	5	98	2	65.2	66.0	50.7	53.7	3.0
14	88	7	22	99	0	67.2	68.4	58.7	61.9	3.2
15	95	4	7	99	1	68.5	68.7	49.8	53.1	3.3
16	97	3	9	100	0	67.5	70.0	56.7	68.2	1.5
17	97	2	3	100	0	67.7	68.5	62.0	65.2	3.2
18	99	1	10	100	0	68.3	69.5	50.1	52.9	2.8
19	88	8	19	95	3	66.0	67.6	58.4	63.3	4.9
20	95	5	13	100	0	67.2	68.8	57.9	61.7	3.8
Total	1859	109	223	1971	18	1344.7	1366.3	1157.8	1225.4	67.6
Mean	93.0	5.5	11.2	98.6	0.9	67.2	68.3	57.9	61.3	3.4

Yield test plot planted May 15.

The data in table 20 show a field germination difference in favor of treatment only for Merko as a whole in 1934. Drouth was severe in this latter plot and moisture conditions in the soil were far from uniform. No yields were obtained because of drouth.

In 1935, 10 lots of corn were prepared, each divided into four sub-samples representing untreated and treated with Merko, New Improved Semesan Jr. and an experimental dust. The planting was made in 24-hill rows, each sub-sample being replicated six times. The yield data are shown in table 21. Analysis of variance showed that the difference in yields from Merko and Semesan Jr. treated seed was just short of significance. Similarly the difference in yield between the check and the experimental dust was not highly significant. Yields from Merko and Semesan Jr. treated seed above the check were highly significant.

The planting made in 1936 (plot 4, table 18) was with different grades of corn produced in 1935. The samples were small in a number of cases, hence only 150 kernels each of treated and untreated per lot were planted. The "t" test indicated that the difference due to treatment was not significant as a whole.

DISCUSSION OF CORN TRIALS

In the years 1933-36 a total of 123 samples of corn repre-

TABLE 20. PERCENTAGE FIELD GERMINATION TREATED AND UNTREATED CORN IN IOWA IN 1934.

Sample no.	Check	Barbak	Merko	Semesan, Jr.
1	87.9	89.7	92.4	88.1
2	90.8	87.3	89.4	89.6
3	89.3	87.6	89.7	86.7
4	88.9	86.2	84.7	88.6
5	90.7	92.2	92.8	90.5
6	85.0	87.2	91.1	88.6
7	87.2	89.1	91.4	88.4
8	87.5	90.2	90.6	89.3
Mean	88.4	88.7	90.3	88.7

Plot planted May 16.

senting hybrids and open-pollinated varieties was tested in the laboratory to determine percentage of viability and of seeds infected with dry rot fungi. Both treated and untreated samples were tested, from which results were obtained indicating that mercury dusts significantly increased the germination and effectively controlled the dry rot fungi present on viable seeds. Samples which were increased in germination by treatment in the laboratory usually responded in a similar manner when planted in the field, although differences between treated and untreated sub-samples were less marked. The control of the same saprophytes as noted in the barley tests by seed treatment was observed in the corn samples. It is believed that the control of such organisms in addition to the control of parasites may in part account for the greater increase in germination in the laboratory than in the field as a result of treatment.

In 1933 no significant increase in yield was obtained by seed treatment of 40 samples representing entries in the Iowa State Corn Yield Test. Conditions for germination in the spring were favorable and the lots represented high

TABLE 21. YIELD OF TREATED AND UNTREATED CORN IN IOWA IN 1935.

Sample no.	Bushel per acre						
	Check	Merko	Gain over check	New Impr. Semesan Jr.	Gain over check	Experimental dust	Gain over check
1	68.7	70.0	1.3	66.6	-2.1	64.5	-4.2
2	79.3	88.6	9.3	87.6	8.3	82.1	2.8
3	70.8	74.9	4.1	73.4	2.6	67.8	-3.0
4	80.1	85.2	5.1	91.9	11.8	82.4	2.3
5	80.5	86.9	6.4	86.1	5.6	86.5	6.0
6	81.5	78.9	-2.6	82.9	1.4	78.1	-3.4
7	74.2	84.9	10.7	82.5	8.3	81.2	7.0
8	73.8	84.2	10.4	79.4	5.6	78.2	4.4
9	77.8	80.6	2.8	80.0	2.2	79.1	1.3
10	60.9	64.7	3.8	63.4	2.5	64.4	3.5
Mean	74.8	79.9	5.1	79.4	4.6	76.4	1.7
Pct. gain			6.8		6.2		2.3

Plot planted April 28 and 29.

quality seed. In 1934 and 1935 a total of 50 seed lots was used. Significant increases in yield as a result of treatment were obtained, the mean increases being 2.9 and 5.1 bushels in 1934 and 1935, respectively.

The applicability to seed laboratory practice of techniques for detecting seed-borne dry rot fungi and of seed treatment as a part of germination procedure was adequately demonstrated. Response in the laboratory was found to be a reasonably reliable index of that in the field.

LITERATURE CITED

- (1) Bressman, E. N. The effect of land plaster applied as a dust on seed corn. *Phytopath.*, 19:1131-1133. 1929.
- (2) Burnett, L. C. and Reddy, C. S. Barley in Iowa. Iowa Agr. Exp. Sta., Bul. 367. 1937.
- (3) Christensen, J. J. Association of micro-organisms in relation to seedling injury arising from infected seed. *Phytopath.*, 26:1091-1105. 1936.
- (4) Crozier, W. F. Detection and identification of seed-borne parasites. *Proc. A. O. S. A.* 1935:87-92. 1936.
- (5) Durrell, L. W. Dry rot of corn. Iowa Agr. Exp. Sta., Res. Bul. 77. 1923.
- (6) Durrell, L. W. Basisporium dry rot of corn. Iowa Agr. Exp. Sta., Res. Bul. 84. 1935.
- (7) Holbert, J. R., Reddy, C. S. and Koehler, B. Chemical dust seed treatments for dent corn. U. S. Dept. Agr., Dept. Cir. 34. 1928.
- (8) Koehler, Benjamin and Holbert, J. R. Corn diseases in Illinois. Ill. Agr. Exp. Sta., Bul. 354:1-164. 1930.
- (9) Koehler, Benjamin. Seed treatments for the control of certain diseases of wheat, oats, barley. Ill. Agr. Exp. Sta., Bul. 420. 1935.
- (10) Melhus, I. E., Reddy, C. S., Raleigh, W. P. and Burnett, L. C. Seed treatment for corn diseases. Iowa Agr. Exp. Sta., Cir. 108. 1928.
- (11) Munn, M. T. The seed analyst's responsibility with reference to seed-borne diseases. *Proc. A. O. S. A.* 1919:31-34. 1919.
- (12) Porter R. H. Effect of seed-borne pathogens and of seed disinfectants on the germination of barley seed. *Proc. A. O. S. A.* 1935:94-99. 1936.
- (13) Porter, R. H. Relation of seed disinfectants to seed analysis. *Proc. A. O. S. A.* 1936:93-101. 1936.
- (14) Porter R. H. Pathological aspects of seed analysis. *Proc. A. O. S. A.* 1931. In press. 1938.
- (15) Porter, R. H. Detection of seed-borne pathogens. *Proc. A. O. S. A.* 1932. In press. 1938.
- (16) Raleigh, W. P. Infection studies of *Diplodia Zeae* (Schw.) Lev. and control of seedling blights of corn. Iowa Agr. Exp. Sta., Res. Bul. 124. 1930.
- (17) Reddy, C. S. and Burnett, L. C. Flax as an Iowa crop. Iowa Agr. Exp. Sta., Bul. 344. 1936.
- (18) Snedecor, G. W. Analysis of variance and covariance. Collegiate Press, Inc. Ames, Iowa. 1934.
- (19) Snedecor, G. W. Statistical methods. Collegiate Press, Inc., Ames, Iowa. 1937.
- (20) Shands, R. G. Longevity of *Gibberella saubinetii* and other fungi in barley kernels and its relation to the emetic effect. *Phytopath.* 27:7:749-762. 1937.

